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## GLACIATION IN AUSTRALIA.

BY T. S. HALL, CASTLEMAINE, VICTORIA, AUSTRALIA.

EVIDENCES of one or more glacial epochs are plainly visible in Australia, and the more closely is study directed to the subject, the more widely spread are the glacial deposits found to be. As long ago as 1861 Selwyn, then the Director of the Geological Survey of Victoria, noted that several conglomerate beds in various parts of the colony were evidently the results of ice-action, although no striated stones were visible. In 1877 Professor Tate of Adelaide announced the discovery of a glaciated surface near that city, and toward the close of 1889 Mr. E. J. Dunn found grooved stones in Victoria. Since then the Mining Department of Victoria has issued a report by Mr. Dunn of one of these conglomerate beds near Heathcote. The deposit covers about 36 square miles, and consists of a base composed of dark indurated clay, through which are scattered masses of rocks of various kinds—granites, syenites, gneisses, schists, quarzites, slates, shales, conglomerates, etc., etc. Many of the granites are not known in Victoria, *in situ*, and their origin can only be guessed at at present. In one or two places glaciated surfaces are seen and the striæ run north and south. The largest "erratic" known is a block of extra-Victorian granite, weighing about 30 tons. The thickness of the beds is estimated at about 400 feet. The bed rock is of Lower Silurian age, and is tilted at a high angle. Intercalated beds of sandstone occur in places, and show the deposit to be still nearly horizontal. In a paper recently read before the Royal Society of Victoria, Messrs. Officer and Balfour record grooved pebbles, "contorted till," and glaciated surfaces near Bacchus Marsh. The deposit there has, moreover, been heavily faulted.

The age of the Victorian deposits has not been precisely fixed as yet. At Bacchus Marsh the beds are overlain by fresh water sandstones containing *Gangamopteris*, *Schizoneura*, and *Zeugophylletes* (?), and which are stated by M'Coy to be of Triassic age. The age of the glacial beds is then perhaps Palæozoic. No fossil remains have as yet been found in the glacial beds themselves, but doubtless careful washing of the clays will yield evidences of life, as it has done in other countries. Small outliers of these beds are found widely scattered over the colony, from north to south, and on both sides of the Dividing Range. They extend into New South Wales, and may be looked for, Dunn says, at the foot of the western slopes of the Great Divide. Similar beds occur on the eastern edge of the great Queensland Downs

Mr. Dunn draws a parallel between these beds and the Dwyka conglomerates of South Africa, which are of Triassic age. If the parallel prove a good one, then we have evidence of an enormous extent of glaciation at the close of the Palæozoic or the beginning of the Mesozoic, extending nearer the equator than that of the Northern Hemisphere, during the last great ice age. The South Australian beds at Hallett's Cove, near Adelaide, before alluded to, are of Tertiary age. Here the glacier path can be traced for about two miles, and moraine *débris* is in abundance. Traces of more recent glacial action are recorded from the neighborhood of Mount Koscius Ko, but these are of local origin, and are perhaps due to a greater elevation of the region, as no glaciers exist in Australia at the present time.

## SECRETS OF THE ATMOSPHERE.

BY H. A. HAZEN, WASHINGTON, D.C.

IN the March number of the *American Meteorological Journal*, Professor Harrington treats at some length the subject, "Exploration of the Free Air." and urges the great necessity of such an enterprise. For more than eight years the present writer has insisted that by no other means will it be possible to set the science of meteorology upon a firm basis and rid it of mere speculations and theories which too often have served to prevent its advance in the past. Professor Harrington quotes a graphic description of an experience of the aeronaut Wise, in which he seemed to be thrown or attracted back and forth in an ominous thunder-cloud. Several such have been described by aeronauts, who unfortunately had not the instruments requisite to give very necessary information in these cases and to make them of avail in a scientific study. The description of these mysteries make us long for something more tangible and definite.

To my mind there is no research of so great importance in the whole range of science as that of a few well conducted ascensions, with accurate instruments, in the midst of a rain-storm and on all sides of a low area. Ordinarily, balloon voyages have been made during clear weather and for the benefit of a great assemblage, so that this field, or the problem of ascertaining the secrets of the air, has been almost entirely neglected up to the present. A single illustration will show the extreme necessity of systematic work in this line.

It may not be generally understood that there has been an extraordinary revolution in meteorology within the past six years. During this revolution the whole convection hypothesis of storm generation, without the least doubt the most important of all the theories of orthodox meteorology, has been attacked and completely overthrown. The significance of this defeat cannot be exaggerated and should be fully set forth. The convection theory is fully advanced in Professor Ferrel's last book, published in 1890, "A Popular Treatise on the Winds," p. 228. "On account of the non-homogeneity of the earth's surface, comprising hills and valleys, land and water, and dry and marshy areas, all with different radiating and absorbing powers, and also on account of the frequently irregular and varying distribution of clouds, it must often happen that there are considerable local departures of temperature from that of the surrounding parts; and if it should so happen, as it frequently must, that this area is of a somewhat circular form, and the air has a temperature higher than that of the surrounding part of the atmosphere, then we have the conditions required to give rise to a vertical circulation, with an ascending current in the interior, as described above. But unless there is some source of heat by which this interior higher temperature is kept up, this circulation soon ceases, for the interchange of air between the interior and exterior parts of the air comprised in the circulation tends to continually reduce the difference of temperature upon which the circulation depends, and to bring all parts to the same temperature. . . . In the case of a moist atmosphere with the unstable state for dry air, we have the same energy for originating and maintaining a vertical circulation as in the case of dry air, with the additional energy of all the latent heat of the aqueous vapor set free in its condensation